INTRODUCTION TO SESSION ON MATERIALS AND STRUCTURES

Louis F. Vosteen
NASA Langley Research Center

Activities at Langley Research Center on the development of composites for aircraft can be divided into two main areas: supporting base technology and the Aircraft Energy Efficiency Composites Program. The principal elements of the supporting base technology program are

Environmental effects on materials
Material quality and chemical characterization
Design and analysis methods
Structural durability
Impact sensitivity
Carbon fiber electrical effects

The work on environmental effects on materials is covered in the paper by Pride. The work on material quality and chemical characterization is aimed at consistent quality and is confined at present to work with epoxy resin systems; fiber quality is not being addressed: First, the significant variables that affect quality are being determined. Second, the quality required to meet the aircraft composite needs that are expressed in terms of these variables will be established. Third, reliable methods for monitoring material quality will be developed. Special test techniques may be required. In so far as possible, techniques will be standarized so that suppliers, users, and new material developers can relate their data. The goal is to assure consistent, acceptable materials for aircraft use.

One aspect of the NASA work on design and analysis methods will be covered by Stroud and Sobieszczanski-Sobieski.

The elements of the program on structural durability are

Design methods for fatigue
Fracture characteristics
Fail safe designs
Joints
Bonded reinforcements

The emphasis here is on the development of analytical methods although some of these methods may be based on empirical relationships.

Some composite materials, particularly graphite epoxy, are impact sensitive. Work being conducted at Langley Research Center on impact sensitivity is both analytical and experimental. Experimental efforts are used to help define the significant variables governing the sensitivity of composites to impact and also to evaluate the analytical methods that are being developed. The impact sensitivity of composites is related to the operating strain level. Below a certain strain, impacts do not appear to cause damage that propagates readily. The crashworthiness of aircraft that use composite materials is one aspect of the impact sensitivity problem that will be discussed by Stone.

Recently, the government announced that it was initiating a program to investigate the affects of carbon fiber on electrical components. Carbon fibers are electrical conductors; free fibers in contact with an unprotected electrical circuit can cause shorts, electrical arcing, or resistive loading. It should be noted that fibers confined in a plastic matrix do not pose any electrical hazard. Several of the ways in which free carbon fibers can be released into the atmosphere, and thereby pose a potential hazard, are

Industrial operations
Scrap and waste disposal
Destructive testing
Incineration of products
Aircraft crash and fire

Of these items, all but aircraft crash and fire can be fairly well controlled at their origin. However, aircraft crash and fire could result in uncontrolled release of fibers if the binding matrix material is burned away cleanly and the fibers become airborne. Graphite fibers used in aircraft composites are extremely fine and can float long distances from their point of release. The NASA program to investigate graphite-fiber electrical problems is in two areas. The first area is to better quantify the potential problem of using composites on civil aircraft. This includes a better understanding of the way in which carbon fibers can be released in the event of an aircraft crash and subsequent fire, the propagation of fibers away from the fire site, and the vulnerability of electrical components, especially in other aircraft and in the surrounding area. The second area, in parallel with this activity to better quantify the problem, is to develop materials that will alleviate or eliminate the electrical hazard. These programs will include modifications or changes in the resin system which would prevent the release of fiber following a fire and the development of nonconductive fibers to replace graphite.

The two principal activities of the Aircraft Energy Efficiency Composites Program are the development of composite components and wing-study activity. The components being developed, by company, are

The Boeing Commercial Airplane Company:

727 elevator
737 horizontal stabilizer

Douglas Aircraft Company:

DC-10 upper aft rudder
DC-10 vertical stabilizer

Lockheed-California Company:

L-1011 inboard aileron
L-1011 vertical stabilizer

The status of the development of these components is covered in part in the papers by Stone, Stauffer and James, and Buffum and Thompson. Wing-study activity is currently nearing completion. The principal goal of the studies is to define the specific technologies that will be required in order to proceed with large primary structure such as the wing.